Information Guide & Challenge Rules

A Middle School Engineering Competition

NASA Langley Research Center
New Horizons Regional Education Center
Hampton, Virginia

December, 1998

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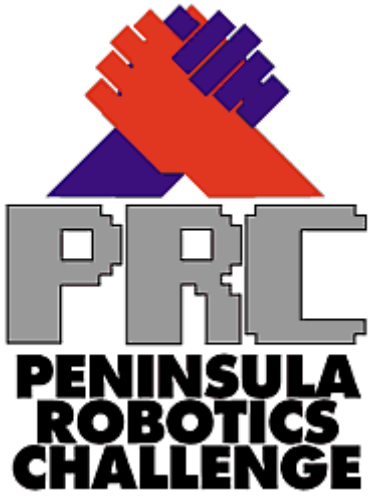

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I. Introduction

Expanding on the1997-98 FIRST robotics partnership between the NASA Langley Research Center and the New Horizons Regional Education Center, the Peninsula Robotics Challenge (PRC) is becoming a reality during the 1998-99 school year. The PRC will bring practical understanding of math, science, and engineering to hundreds of middle school students on the Virginia Peninsula, while generating enthusiasm for pursuing these areas in future studies. How will this be accomplished? Teams of students from middle schools across the Virginia Peninsula will design, build, program, and test their own autonomous (self-operating) robots and then compete head-to-head with robots designed by other schools. The PRC is designed to be co-curricular, integrated into a variety of classroom subjects. It extends beyond the construction of the robot to include written and oral presentations as well as a required mentorship involving elementary age students from a school's local area. Teams can consist of any number of students, although 3-5 students will be responsible for officially representing their team during the final challenge event. Participation in the PRC is limited during the 1998-99 school year because it is currently only a pilot program. It is anticipated that in successive years a larger regional competition will take place, culminating in a nation-wide challenge open to all middle schools across the country in the 2000 school year.

The PRC is being developed in collaboration with many of the major K-12 educational associations including: the National Science Teachers Association; the International Technology Education Association; the Technology Student Association; the National Association for secondary School Principals; and the National Association for Elementary School Principals. Through the generous sponsorship of partners like Pitsco/LEGO Dacta and National Instruments,

the registration fee for a school to participate in the Peninsula Robotics Challenge is only $125. Teams will receive approximately $500 worth of robot building parts which will be supplied to each team in a kit during the PRC orientation meeting. The materials provided as part of the PRC become the property of the participating school at the PRC orientation. It is anticipated that these materials will be valuable classroom resources long after the final challenge is complete.

The New Horizons Regional Education Center will be serving as the coordinating educational agency for the PRC, as well as NASA Langley's partner in the national FIRST competition once again this year. While there are a number of awards that will be given out as part of the PRC, the award for the Overall Challenge Champion (which will take into account all elements of the PRC, not only the head-to-head competition) will be invited to accompany the NASA/NHREC FIRST team to a regional FIRST competition in New England or Florida during the Spring of 1999. Three students (accompanied by one teacher/adviser) will train with the high school team to become operators of the 1999 FIRST robot in anticipation of the PRC champions serving as operators of the FIRST robot during the regional competition. Teams interested in participating in the 1998 Peninsula Robotics Challenge should make their registration payment to the New Horizons Regional Education Center. Below is a tentative timeline for the 1999 PRC:

September 28	Registration forms distributed to invited middle schools
December 2	Registrations due
December 9	Orientation meeting at NHREC

Choose only one of the following two dates to attend:

January 5	RCX and ROBOLAB tutorial at NHREC
January 6	RCX and ROBOLAB tutorial at NHREC

February 8-11	Oral presentations to executive panel; submit written reports
February 13	PRC head-to-head competition and awards presentation at the Virginia Air and Space Center

Also, PRC organizers will be available to respond to questions dealing with challenge logistics and rule interpretation each Wednesday in January. Please see the PRC website at http://k12unix.larc.nasa/gov/projects/PRC for further information.

II. The Challenge

You, along with teams of other experts throughout your region, have been asked by NASA to design a robot for an upcoming mission. Using the latest technology aboard a space-based telescope, a new planet has been discovered that could contain critical information on the formation of our solar system. This small, newly discovered planet, named Nebulon, has been photographed only once by a spacecraft which transmitted a single image of Nebulon's surface back to earth before an electrical malfunction completely shut down the spacecraft's communication systems and ground controllers lost contact with it. This single digital photo revealed an amazing arrangement of rocks sitting on the planet's surface, so a mission to place a robotic vehicle on Nebulon has been scheduled for late next year. You must design and construct a robot that will collect the rocks found on Nebulon for analysis. In the image of Nebulon's surface, directly opposite the proposed landing site, there are two rocks which are very different from all of the others - these are of even greater value to the scientific community here on Earth due to their uniqueness. Your initial analysis can be completed onboard the robot itself by using a special sensor package that NASA will provide to the team that is selected for this mission. A more complete analysis of the rock samples will be conducted here on Earth as part of the second mission to Nebulon, which will occur 2 months after the conclusion of your operation. This second mission will collect the specimens that you leave in one of two "drop zones" and return them to Earth for detailed study by a team of expert scientists, so it is imperative that you place as many samples as possible into the drop zone, even if you do not collect them for analysis onboard the robot itself.

Other countries are likely to attempt the same mission, so there is the possibility of encountering additional robots on the surface of Nebulon. These robots will most likely be searching for the same samples that you are seeking, so speed and possibly a defensive strategy are essential! Also note that your robot must be designed to complete the mission within two minutes since Nebulon's harsh environment will prevent your robot from operating after this point, even though the parts provided in each team's kit are "Nebulon approved". Finally, the rocket which will carry your robot on its journey to Nebulon has a payload envelope of only 12 inches wide by 12 inches deep by 8 inches high, thus your robot must not be any taller than 8 inches and fit within a one foot square area for launch, although it may expand once it becomes operational.

A recent innovation in propulsion methods will allow your robot to make it to the surface of Nebulon in record-breaking time, but time is short - you only have 9 weeks to design, build, program, and test your robot before the final selection by NASA officials. In order to determine the robot that is best suited for this mission, NASA will hold head-to-head matches between different design teams. Your team will also be required to present a brief oral summary of your design to an executive panel, along with a written report documenting your project. Finally, it is very important to communicate the work that you are involved with to others, so you are expected to keep at least one group of students from a local elementary school informed of your team's progress.

Good Luck!

III. Training:

There will be a 1-hour orientation meeting at the beginning of the PRC where teams will receive their kit of parts. Materials providing guidance on how to build structures and use the various motors and sensors will be included as part of the PRC kit. Instructions will also be provided with the ROBOLAB software package to aid in programming the robot's control system. A basic introduction to the construction and programming of a non-tethered robot using the kit parts will be provided during the orientation, followed by a question and answer session. An afternoon tutorial will be offered on January 5 and January 6th, 1999 to provided lead teachers and/or mentors with some basic instruction on the use of the ROBOLAB programming language and the RCX controller. Participants will also have an opportunity during the tutorial session to observe some example devices constructed from kit parts, including the ROBOLAB programs used to control these devices, and have the opportunity to examine a full size playing field during the January training session. At the conclusion of the December *orientation* meeting team leaders will have the opportunity to sign up for one of the two January tutorial dates. Teams may send one or two leaders to the tutorial (on the same night), but teams will share a single computer and the materials from their kit.

Resources will be provided as part of the PRC kit to assist teachers and mentors with introducing the concepts of friction, force, torque, gearing, control systems, ratios, and computer programming in their classrooms. Additional materials to support the integration of these concepts may also be available via the PRC website. It is anticipated that the materials used in the Peninsula Robotics Challenge will have many applications in the classroom even after the completion of the PRC. Appendix A contains a matrix of the National Math and Science Standards that are addressed by the major elements of the Peninsula Robotics Challenge.

IV. Robot Proving Grounds:

The robot proving ground, or playing field designed to replicate the surface of Nebulon, is shown in Figure 1. It is a 4'x8' rectangle made of ¾" BC grade pine-faced plywood, available from most home supply warehouse stores. A 1"x2" pine railing extends around the perimeter of the field to prevent balls and robots from leaving the field. The length of the field is divided into the three zones (blue scoring, neutral, and red scoring) by 4 foot lengths of ¾" semi-circular pine molding. Each team's scoring zone is further divided by ¾" semi-circular molding into two corner "goal" areas separated by the starting zone for the opposing team's two colored balls. The entire playing field is painted flat white with the exception of the molding which is painted red, or blue indicating the location on the field.

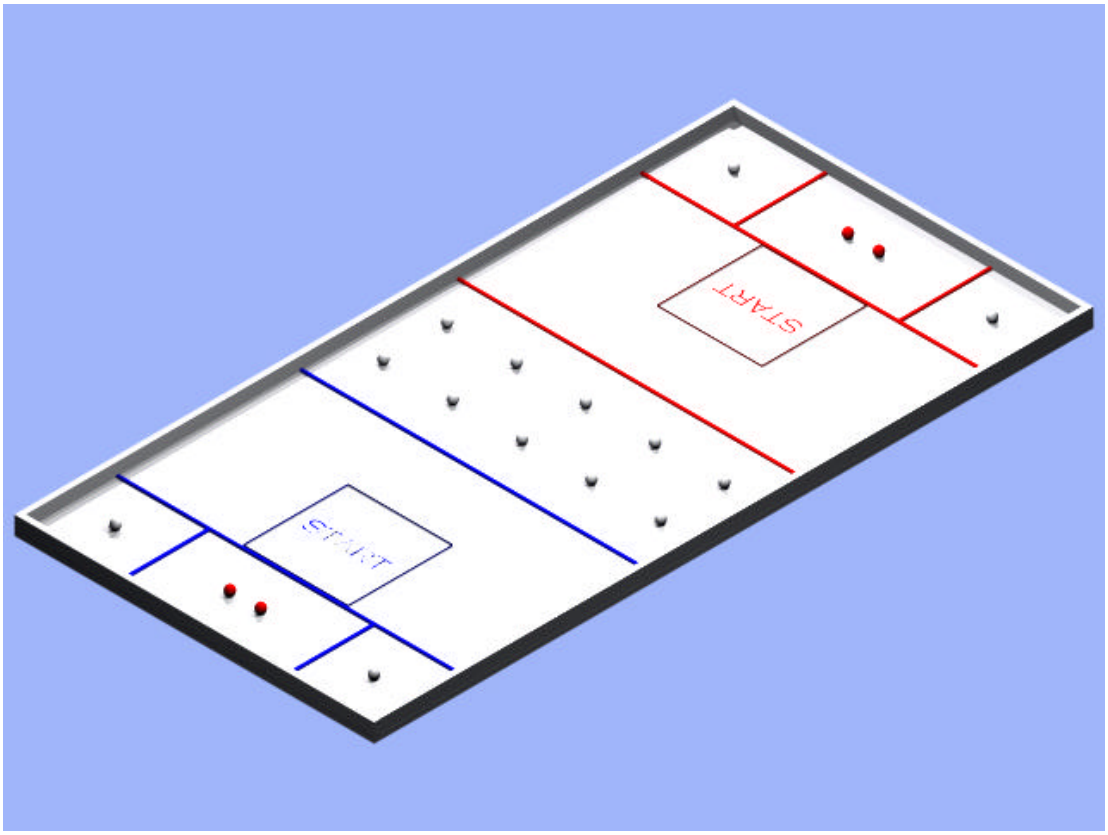


Figure 1: Robot Proving Grounds

The Nebulon rocks will be simulated using white plastic driving range practice balls (the kind perforated with holes throughout), available in golf specialty stores, as well as in department store sporting good sections. There are a total of 18 neutral (white) balls and 4 team (2 blue, 2 red) balls which may be captured by the robots. Each team's colored balls start on the opposite side of the field, centered in the opponent's scoring zone. Ten white balls are lined up in two rows inside of the neutral zone, while the remaining white balls are centered in each of the four "drop zones". The location of each ball is marked by a 1/8" hole drilled through the playing field. The holes also

serve to keep the balls in their initial positions at the beginning of each match. Appendix B provides CAD drawings describing the construction of the Proving Grounds along with the ball placement.

It is *highly* recommended that each team either construct their own playing field for testing, or make arrangements with one or more schools to share a playing field. Please do not arrive at the competition only to discover that your robot will not fit where you thought it would or that it doesn't quite reach as far as you had planned. Teams are also encouraged to contact other participating schools and arrange for "scrimmage" matches to test their robots. While the PRC organizers will not be coordinating these intermediate challenge events, if schools do set them up, please inform the PRC, we might like out and observe!

The materials required to construct a playing field are listed below. A team may wish to construct their own field, share the cost of certain components (glue, screws, paint, etc) with another team, or share a field with one or more teams. The structural support, consisting of 2"x4" bracing below the playing field, is optional and may not be required if your field will not be moved often and will be handled with care. This structural support can be added to the underside of the playing field in either a "criss-cross" or "tic-tac-toe" pattern, securing the bracing members from above the playing field using the wood screws. Please be certain not to place the underside support members below the edge of the field, as this will interfere with the attachment of the field walls, which should be glued and then screwed from the underside. The fields used for the final competition will have all screw holes filled and sanded smooth. And will be placed on tables or supports which will raise them at least 36" above the ground.

Field Element	Material	Est. Cost	Qty	Est. Total
Main surface	4' x 8' ¾" BC Plywood	$18	1	$18
Guard Rail/Border	Pine 1"x2"x8'	$4.00	3	$12
Zone dividers	Pine ¾" half-round molding , 8'	$1.80	5	$9
Structural Support	Pine 2" x 4" x 8'	$2.15	6	$12.90
Fasteners	Screws, 1Lb, #6x2"	$2.60	1	$2.60
Fasteners	Wood Glue	$2.50	1	$2.50
	Wood Filler	$2.00	1	$2.00
Paint: main surface	Flat white	$3.00	2	$6.00
Paint: red zone	Satin red	$3.00	1	$3.00
Paint: blue zone	Satin royal blue	$3.00	1	$3.00
Primer	Wood primer	$3.00	2	$6.00
Balls	Plastic golf practice balls (pkg. of 15)	$3.00	2	$6.00
			TOTAL:	$83.00

Table 1: Estimated Bill of Materials for Proving Ground Construction

V. Scoring:

The head-to-head competition will be arranged as follows: the morning will begin with each team checking in and submitting their robot for an inspection to ensure that only allowable parts are used, that no glue or other substance has been used for structural support, and that the robot will fit within the given size constraints. The morning will then begin with a series of "seeding" matches. The current plan calls for each team to play in at least two matches during this initial phase of the competition. After a lunch break, the morning's results will be used to determine pairings for the double elimination tournament that will select the robot that is the most effective at completing the task. This overall format guarantees that all teams will have the opportunity to participate in a minimum of four matches during the day, with the likelihood of additional matches for each team. Judges will be walking around to observe robots and discuss them with the various teams during the matches. An awards ceremony will follow the final match.

The competition has been intentionally designed with a variety of scoring options. Each team must decide what strategy they will use to maximize their total score, while keeping their opponent's score to a lower total. The table below lists how the judges will determine the score at the end of each match. Points are awarded for balls which are captured by a robot, balls which are in a team's scoring zone, and balls which are in a team's drop zone. For a ball to count as captured, it must be in the possession of a robot in such a way that the robot exerts direct control over the ball. Thus, a captured ball will move with the robot. More points are awarded for each of the team's two colored balls than for the neutral balls. A table describing the scoring structure follows:

Scoring Condition	Points Awarded
Capture neutral ball	2
Neutral ball in scoring zone	2
Neutral ball in drop zone	3
Capture team ball	5
Team ball in scoring zone	10
Team ball in drop zone	15
Capture opponent's team ball	-5
Contact with opponent's team ball during first 15 seconds of match	-10
Opponent's ball in your drop zone	-10
Robot leaving playing field	-10

Table 2: PRC Scoring

Please note that it is possible to combine multiple scoring options to increase a team's score. For example, if a ball has been captured by a robot (2 points) and the robot finishes the match back in

it's own scoring zone, an additional 2 points will be awarded since the captured ball is also in the scoring zone, for a total of 4 points for that individual ball.

The judges at the end of each match will do all scoring. The final score for each match is dependent upon the final position of each robot and all of the balls. Ball positions during the course of the match will not be taken into consideration as the judges determine the final score - it is only the position of each ball at the end of the match that will determine a team's score. At the conclusion of each match, all balls will be allowed to come to rest before the final score is determined. If a robot continues to move at the conclusion of a match and disturbs the position of any balls, the judge will determine the final position of the balls at the match's conclusion and base the score on this positioning

VI. Team Requirements:

Each team participating in the 1998 PRC must complete the following competition elements:

1.) Design, build, and test an autonomous robot from the supplied kit of parts, abiding by all rules and regulations and participate in the PRC head-to-head competition in December.
2.) Develop a 5-minute electronic presentation (PowerPoint or similar) describing the teams approach to the problem, rationale for their chosen design, organization of their team, and strengths/weaknesses of their design. During the week preceding the competition, team representatives will give an oral presentation to a panel of executives from local industry.
3.) Make one or more presentations to elementary students from their school division, describing their robot building project. This presentation must include at least one entire elementary school class, but may be given to a larger elementary audience. The presentation may occur at the middle school, the elementary school, or a neutral location. Teams are encouraged to include these younger students throughout their project. Provide a brief summary/description on this elementary partnership along with the student's written report.
4.) Submit a written paper describing the team's involvement with the PRC including, but not limited to: robot design and construction; robot programming; team organization; assistance from community volunteers; elementary school partnership; and lessons learned. This paper must be submitted on the date of the oral presentation.

It is the responsibility of the teachers and mentors associated with each team to communicate to the students throughout this project the inherent value in beginning and completing a design project such as this. Success for these students is based more upon the process that they go through in completing the various elements of the challenge than it is in the number of awards that they receive on the final day. Team leaders are also expected to model exemplary sportsmanship, fostering this attitude throughout their team. Encourage your students to get to know the members of other teams, even offering help to other teams to overcome a problem or repair a damaged robot. Teach students to find satisfaction in sharing a lesson they learned hard way with other teams. Students learn more through failure (and the subsequent explanation of that failure) than they do from an easy success. This truly is a *challenge* and not a competition. Develop a team mindset of setting high goals and then strive as a team to meet them.

VII. Robot Construction:

Robots must be built solely from the following two sources:

1.) The supplied kit of parts, provided at the competition orientation meeting
2.) No more than $50 worth of parts from the Lego Dacta/Pitsco catalog, pages 74-76.

All parts provided in the PRC kit are identical for each team. Teams are responsible for the cost of any additional parts purchased including spares, replacements, and the $50 of allowable additional parts from the catalog. Teams are not required to buy any additional parts, and may construct their robot solely from the parts supplied in the kit. If a team does buy parts from the catalog and those parts are used on the robot, they must deduct the cost for each item from their $50 total. The price deducted must be the price for the smallest catalog quantity which will account for the parts used on the robot. For example, if a team needs one large balloon tire, they may purchase it from the catalog, but the smallest quantity is 4 for $10.00. Even though they only use one tire on their robot, they must subtract the entire $10.00 from their budget, because they had to buy all four tires to obtain the individual one that they wanted. If a team member already owns a part that is found in the catalog, a team my use this part but must deduct it's value from the $50 budget.

Kit Component	Part Number	Qty
Mindstorms Robotics	Dacta 979719	1
ROBOLAB Software	Dacta 900050	1
Angle Sensor	Dacta 979891	2
Light Sensor	Dacta 979890	1
Micro Motor	Shop at Home 5119	2
Standard 9V Motor	Shop at Home 5114	2
9V Connecting Leads	Dacta 779897	2
Red Plates	Dacta 779929	2
Red Beams	Dacta 779927	2
Balloon Tires	Shop at Home 5281	1
Conveyor Belt Links	Dacta 779938	2
AC Adapter	Dacta 979833	1

Table 3: PRC Kit of Parts

Please note that while teams may buy/use additional supplies and materials other than those listed above as part of prototyping and educational sessions (i.e. students may develop concepts using their own materials from home or those that already exist in a school, or an instructor may order multiple kit parts to use in class) the final robot submitted for competition ***must be constructed only from those parts covered by items 1 and 2 above***. Let's repeat this one more time for clarity: Students can use modeling clay, toothpicks, or their brothers $5,000 collection of Lego's to develop their robot concept, and even test it out. But when it comes to the final competition

with other teams, the only parts on their robot should be those provided in the kit, or those totaling no more than $50 from the catalog.

Each team's robot must be no larger than 12"x12"x8" (12" square base, 8" high) at the start of the competition, although robots may expand under their own power once a match begins. Robots may be smaller than the dimensions listed above. Each robot will go through an initial checkout by the judges on the morning of the competition, and will be placed inside of a box measuring 12"x12"x8". To pass this test a robot must fit into this box with nothing other than the bottom and rear of the box contacting any part of the robot.

PRC organizers will not be responsible for the replacement of any parts. If any component is found to be defective upon receipt, each team is responsible for contacting the manufacturer directly in order to arrange for a quick exchange. The replacement of parts damaged or broken during robot construction, testing, and operation is each school's responsibility.

VIII: RULES

1. Each match will begin with an audible "start signal" such as a horn or whistle
2. At the beginning of each match both teams will be able to place their robot within the 14"x14" start box on their side of the field. Teams may position their robot in any orientation, provided that no part of the robot extends beyond the 14"x14" boundary.
3. Before the start signal, no team member, coach, or spectator may have any part of their body or anything attached to their body, extending over the playing field.
4. Upon receiving the start signal, one member of each team shall reach over the playing field to press their robot's "RUN" button. The team member must immediately withdraw his or her hand, and must have no further interaction with the robot during the competition.
5. No human/robot interaction is allowed during the matches
6. Each match will last for 2 minutes
7. During the first 15 seconds of each match, it is illegal for a team to contact their opponent's team balls (which will be located directly behind them) in any way. Such contact will result in a scoring penalty.
8. Strategies which involve intentionally disabling or damaging another robot are strictly prohibited and will result in immediate disqualification.
9. Robots may not intentionally leave anything on the playing field during the course of a match.
10. Robots must stay on the playing field at all times. If a robot leaves the playing field (falls over the edge) the robot may be placed back on the playing field at the location where it fell, and the team will receive a scoring penalty. *(Please note that the tables will be elevated 36" from the floor, so it is highly unlikely that a robot will even survive such a fall. No time will be allowed for repairs during a match - please design with this in mind!)*
11. There will be no timeouts allowed during any of the matches. If a team is not prepared at the beginning of a match, that round will be forfeited to the opposing team.
12. In the event of a tied score at the end of a match, the following conditions will be used (in the order given) to determine a winner

    A. Highest number of points generated by team balls
    B. Most balls in drop zone
    C. Most captured balls
    D. Most balls in scoring zone
    E. Robot furthest from their opponent's side of the field

12. Robots may be constructed only from parts supplied in the original kit or those purchased from the supplied order form, up to a maximum of $50. An inspection will take place at the beginning of the competition to verify that no additional parts have been used
13. Teams may **not** use glue or any other material not provided in the kit to hold their devices together
14. Kit packaging and storage boxes may not be used as part of the robot
15. Final decisions on the interpretation of all rules shall rest with the PRC officials. Please understand that while every attempt will be made to ensure that judging is accurate and

consistent, *we all make mistakes* and we hope each team will be demonstrate both professionalism and exemplary sportsmanship.

16. Teams are responsible for supplying their own batteries (the RCX uses 4 AA batteries). ***This includes the final competition***. Teams should be certain they have an adequate supply of fresh or rechargeable batteries. PRC organizers will provide none. An AC adapter is provided in each kit. This adapter allows each team to eliminate batteries during initial construction and testing but will not be allowed during any challenge matches.

IX. Contact Information:

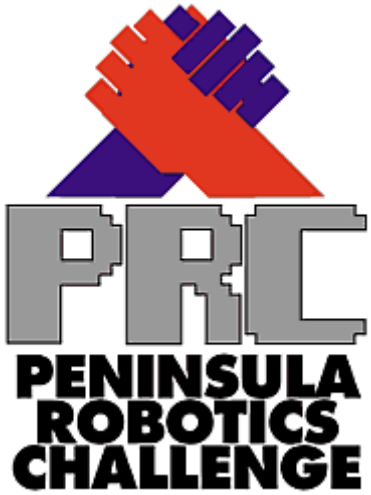
- PRC Website: http://k12unix.larc.nasa.gov/projects/PRC/
  Please check this site often as additional challenge information and rule clarifications will be posted to this location. You may want to assign a student to check this site periodically for new information.
- Email: To communicate with PRC organizers please send all email to the following address:

  prc@k12unix.larc.nasa.gov
- Telephone: If necessary, you can contact John Evans at 864-6665 or Jeff Seaton at 864-6687

X. Awards:

Awards will be given in the following categories:

1.) *Overall challenge champion*
Taking into account scoring from all competition elements (head-to-head: 50%; oral presentation: 20%; written paper: 20%; elementary school partnership: 10%) an overall winner will be chosen and named the PRC overall champion.
2.) *Head-to-head champion*
Based upon a double-elimination tournament, a winning robot will be determined on the day of the competition
3.) *Head-to-head runner-up*
Based upon a double-elimination tournament, a runner-up will be determined.
4.) *Outstanding Oral Presentation*
The team which gives the most professional, clear, and informative oral presentation as determined by the executive panel of judges will receive this award.
5.) *Outstanding Written Presentation*
The team which gives the most professional, clear, and informative written presentation as determined by the competition sponsors will receive this award.
6.) *NASA Langley Award*
Will be given to the team whose robot demonstrates excellence in all facets of design, including reliability, control system, structure, and effectiveness at accomplishing the given task.
7.) *Partnership Award*
Will be given to the team that has developed the most effective network of partnerships with parents, teachers, and local community and industry members and organizations in support of their robot-building effort.
8.) *Most Innovative Robot Design*
9.) *Best Offensive Robot*
10.) *Best Defensive Robot*
11.) *Most Aesthetic Robot Design*
12.) *Most Effective Control System*
13.) *Best Team Spirit*
14.) *Sportsmanship Award*
15.) *Most Unique Robot*



APPENDICES

Appendix A

PRC Integration with National Math and Science Standards

NCTM Math Standards

Standard	Content	Challenge Element 1: ***Design and Construction***	Challenge Element 2: ***Oral Presentation***	Challenge Element 3: ***Written Presentation***	Challenge Element 4: ***Elementary Mentorship***
1	Problem Solving	X			X
2	Communication		X	X	X
3	Reasoning	X			X
4	Mathematical Connections	X	X	X	X
7	Computation & Estimation	X	X	X	
8	Patterns & Functions	X	X	X	
10	Statistics	X	X	X	
11	Probability	X	X	X	
13	Measurement	X			X

National Science Standards Grades 5-8

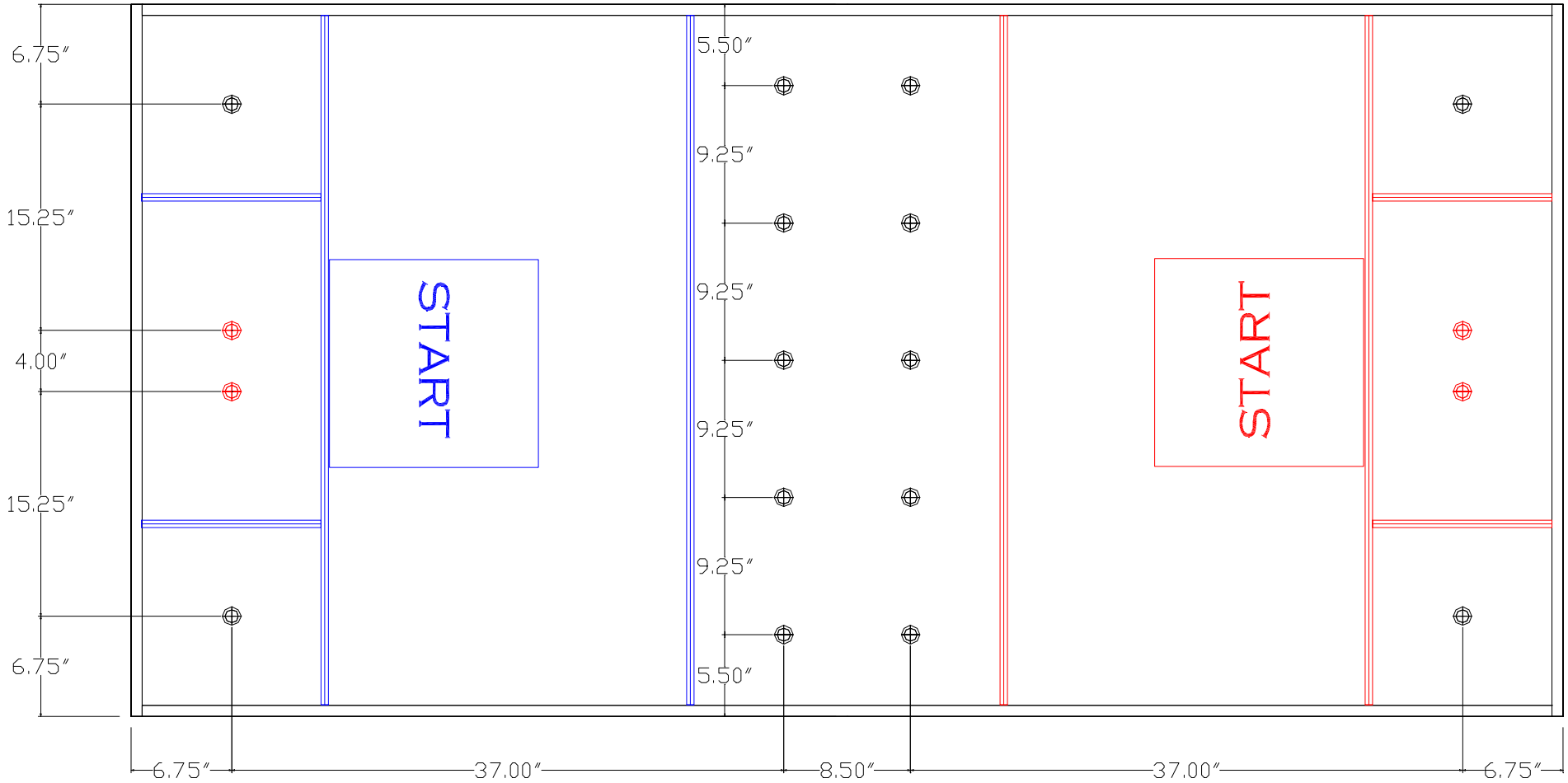
Standard	Content	Challenge Element 1: **Design and Construction**	Challenge Element 2: **Oral Presentation**	Challenge Element 3: **Written Presentation**	Challenge Element 4: **Elementary Mentorship**
Science as Inquiry	Ability to do Scientific Inquiry	X			X
	Understanding about Scientific Inquiry	X			X
Physical Science	Motions & Forces	X	X	X	X
	Transfer of Energy	X	X	X	X
Science and Technology	Abilities of Technological Design	X			X
	Understandings about Science & Technology	X			X
Science in Personal & Social Perspective	Science & Technology in Society		X	X	
History and Nature of Science	Science as Human Endeavor		X	X	

Appendix B:

Proving Ground

Construction Diagrams

Nebulon Mission
Estimated Rock Locations
1999 Peninsula Robotics Challenge



Nebulon Mission
Proving Ground Dimensions
1999 Peninsula Robotics Challenge